XXIX. *A Deſcription of a new Thermometer and Barometer: In a Letter to the Right Honourable* George *Earl of* Macclesfield, *Preſident of the Royal Society, from* Keane Fitzgerald, *Eſq; F. R. S.*

My Lord,

Read May 7, 1761.

I Took the liberty of addreſſing a paper to your Lordſhip laſt year, with an account of an inſtrument, which was intended to anſwer, in ſome meaſure, the purpoſes of a thermometer and pyrometer. The degrees the index had pointed to, during the abſence of an obſerver, were marked by a pencil applied to it. But I found great inconvenience from the friction of the pencil, which muſt be ſtrong, or it does not mark diſtinctly; beſides the trouble of rubbing out the mark, every time a new obſervation was intended.

I muſt beg leave to trouble your Lordſhip with the deſcription of an inſtrument on the ſame principle, as a thermometer only, with regiſters to mark the leaſt variation that can happen during the abſence of an obſerver, which are ſet for any future obſervation, with the greateſt eaſe. As this inſtrument is, in part, like the former, I ſhall only mark the variations from it.

The firſt bar A is fixed at the upper end, by three ſcrews *b*, *b*, *b*, and joined at the lower end to the arm of the firſt lever, by a pin *c*, which paſſes through both. [*Vide Tab.* V.]

fig. 1.

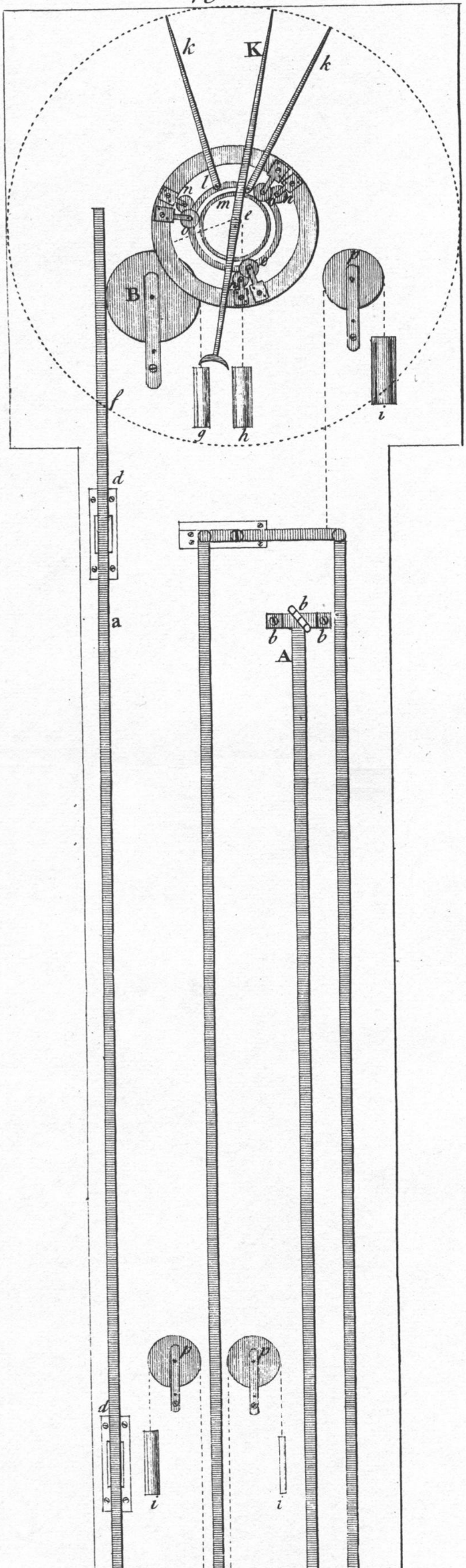


fig. 2.

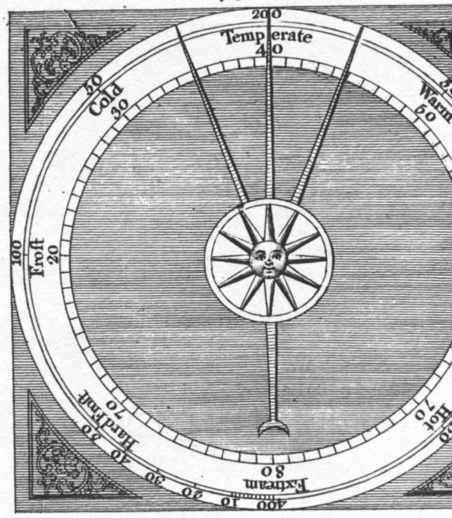
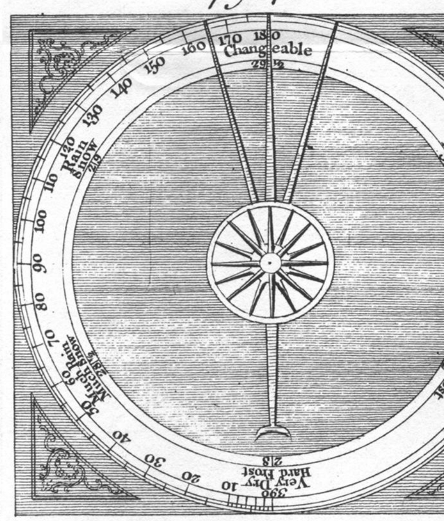
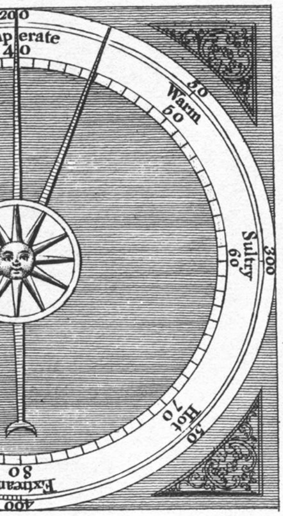


fig. 4.



. 2.


200
40
30
Warm
50
Sultry
60
300
Hot
70
50
80
400

.4.

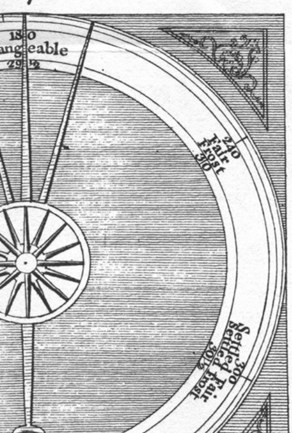
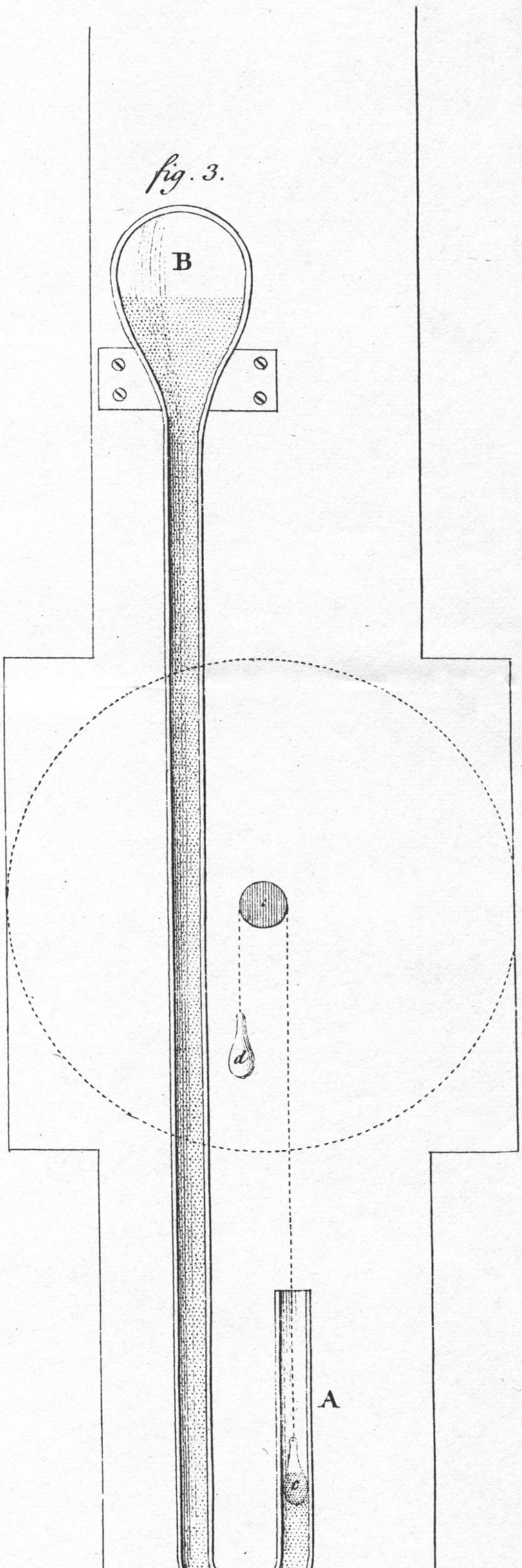
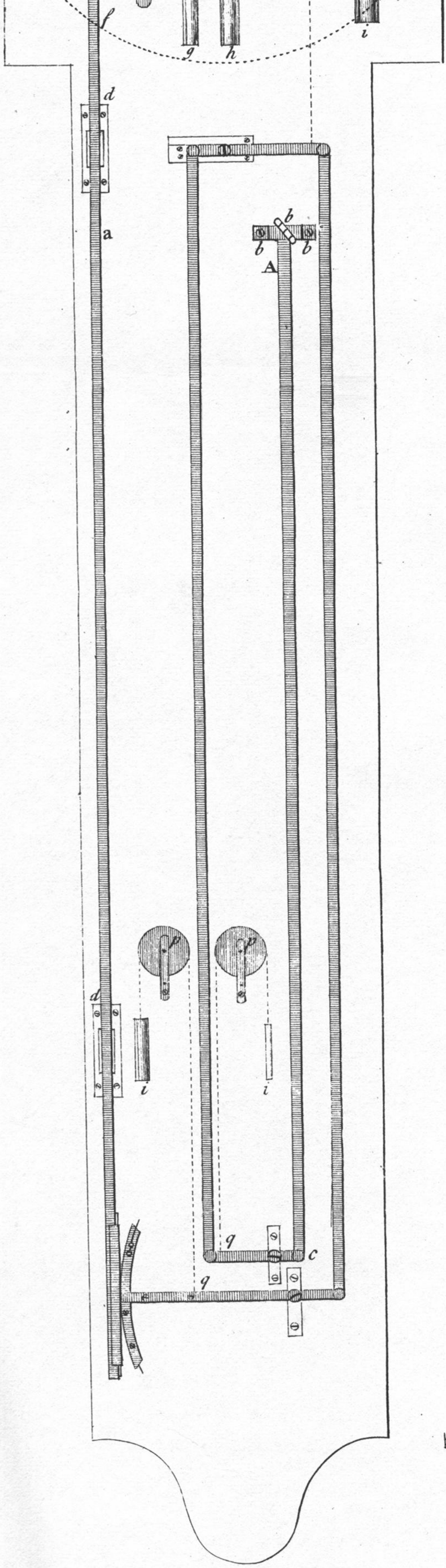

180
210
Fair
Frost
300
Settled Fair
28
Very Dry
Hard Frost
390

fig. 3.

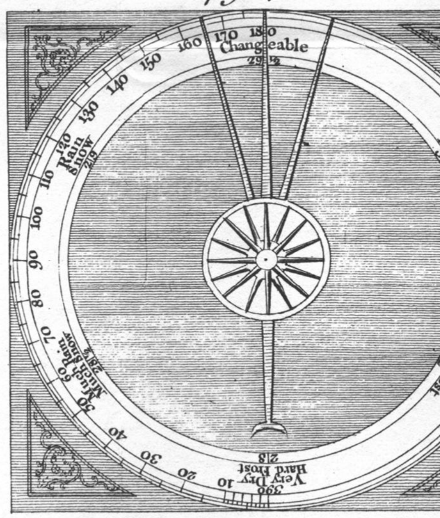

B
d
A
c



f
g
h
i
d
a
b
A
p
c
q

Extream
80
400 10 20 30 40

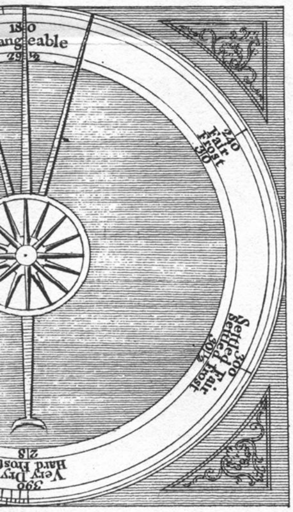
fig. 4.

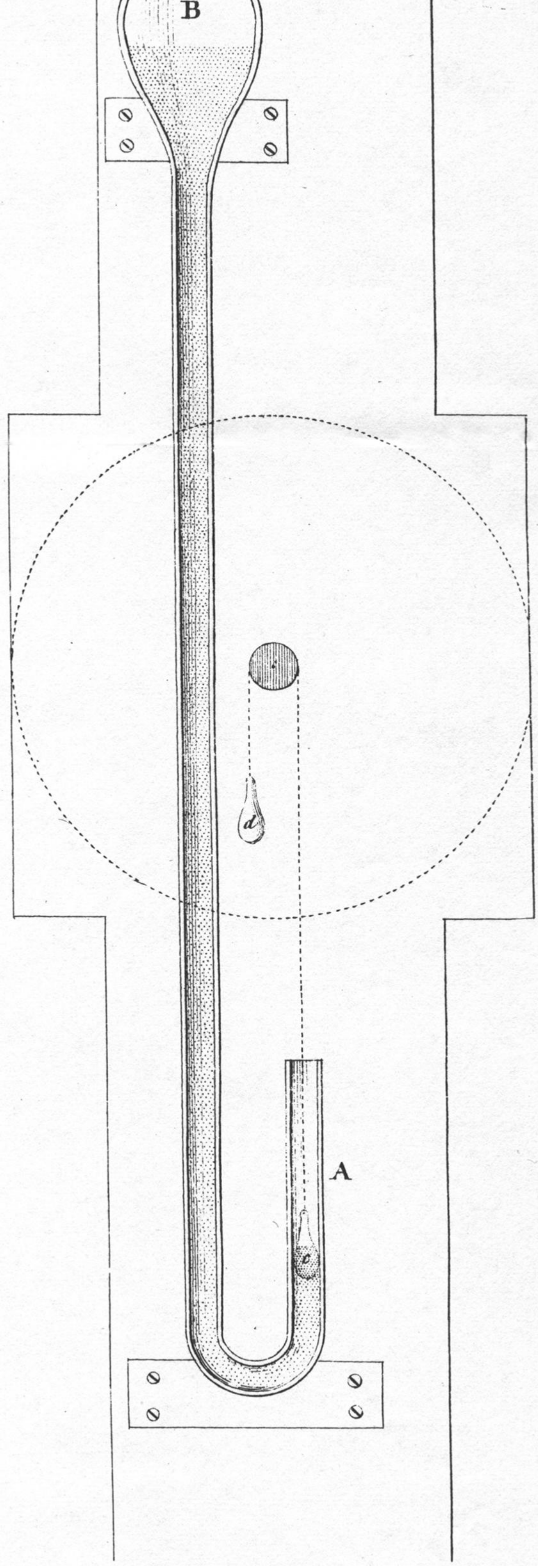


170 180
Changeable
160 150 140 130 120 110 100 90 80 70
Rain
Snow
Much Rain
Snow
40 30 20 10
Hard Frost
Very Dry


80
Extrem
400

.4.


180
angeable
240
Fair
Frost
300
Settled Fair
Very Dry
Hard Frost
360


B
d
A
c

J. Mynde sc.

The fourth bar *a* moves upon two ſmall pullies *d*, *d*, placed under it, and alſo a large pulley B, placed at the ſide of the bar, towards the upper end. In each of theſe pullies, there is a deep groove for the bar to paſs freely, without touching the ſides; and on each ſide of the groove of the pulley B, there is a channel cut for a thread to paſs, which is fixed to the fourth bar, by a hook at *f*, and has a weight ſuſpended at the other end. The thread placed in the inward channel, paſſes alſo over a ſmall pulley *e*, about $\frac{1}{2}$ inch diameter, on the axis of which the index K is placed. The two weights *g* and *h*, ſuſpended to theſe threads, ſerve as a counterballance to the fourth bar, and keep it in contact with the pulley B, which turns with the bar as it moves.

Each of the levers is counterballanced by a weight *i*, at the end of a thread, which paſſes over a pulley *p*, placed above the lever, towards the end of its longer arm, and faſtened to it by a hook at *q*. In adjuſting theſe weights, it is neceſſary, that each lever ſhould preponderate a little towards the ſhorter arm, in order to keep that end cloſe to the bar placed on it. The counterballance weights of the fourth bar are ſo much lighter, as to allow a ſuperior gravity to the bar, ſufficient to turn the index and regiſters; by which means, all the levers bear the ſame way, whether the bars are contracted or expanded.

The axis of the ſmall pulley *l*, on which the index is placed, moves on friction wheels applied to each end. There are two regiſters, or ſlender hands, *k*, *k*, each of which is placed on a circle of braſs *l* and *m*, *l* about $2\frac{1}{2}$ inches diameter, and *m* $2\frac{1}{4}$, placed a little more forward than *l*, ſo as to admit each to

move freely, without touching the other. These circles turn, each upon three friction pullies *n*, *n*, *n*, and *o*, *o*, *o*. The registers, which are very slender, are counterballanced by a small weight placed on the opposite side of the circle, and moved by a pin, which passes through the index, and takes one along with it, as it moves one way, leaving it at the extreme point it has moved to, and, on its return, carries the other along with it, leaving it in the same manner at the other extremity. The index and registers are carried round the dial-plate very freely, by a weight of 8 grains.

As this instrument was intended only to mark the common degrees of heat and cold of this climate, which, according to Fahrenheit's scale, is seldom above 80, or below 0, I regulated its range by the following proportions, founded on Mr. Smeaton's table of the expansion of metals, the experiments I had made on spelter and brass corresponding pretty exactly.

Greatest expansion of the first bar of spelter from freezing to boiling water $\frac{353}{10,000}$ parts of an inch per foot, 2 feet long, $\frac{706}{10,000} \times 3$, the power of the first lever, $= \frac{2118}{10,000}$.

Ditto of the second bar of hammered brass, 2 feet 2 inches long, $\frac{487}{10,000} + \frac{2118}{10,000} = \frac{2605}{10,000} \times 3$, the power of the second lever, $= \frac{7815}{10,000}$.

Ditto of the third bar, 2 feet 3 inches long, $\frac{506}{10,000} + \frac{7815}{10,000} = \frac{8321}{10,000} \times 4$, the power of the third lever, $= \frac{33,284}{10,000}$.

Ditto

Ditto of the fourth bar, 2 feet 6 inches to the place where the threads are hooked on, $\frac{562}{10,000} + \frac{33,284}{10,000} = \frac{33,846}{10,000}$, almoſt $3\frac{4}{10}$ inches, the ſum of the greateſt expanſion of the ſeveral bars, increaſed by the powers of the levers. This is × 30 by the pulley, on the axis of which the index is placed, and carried round a dial 10 inches diameter.

I take ſomewhat leſs than $\frac{1}{3}$ of the greateſt expanſion from freezing to boiling water, to be about a medium of the common degrees of heat and cold of this climate, which makes one revolution of the index. The inward circle, Fig. 2. is divided into 80 parts, correſponding with 80° of Fahrenheit's. Each of theſe is divided into 5 parts on the outward circle, one of which is as large as 2° of Fahrenheit's.

I have compared this inſtrument with a mercurial, and ſpirit thermometer along with it, for ſome time paſt; and have obſerved, that it conſtantly begins to mark the change before either; though the mercury, in ſome time, when the room beeomes warm by fire, or otherwiſe, riſes a degree or two above it. When the room is warmed to any great degree, it riſes ſomewhat higher than the mercury, and, at the ſame time, the ſpirit riſes higher than either, though, on the firſt degree of warmth, it does not riſe as faſt as either.

The metalline thermometer has this advantage over any other, that its range may be increaſed to any degree intended. I have one which carries the index 72 inches, by the common changes of the weather, which may be raiſed 50 or 60°, by blowing one's

one's breath five or ſix times on the firſt bar. It marks the 282,000th part of an inch per foot expanſion, and the powers of the levers, are ſo eaſily increaſed, by the help of counterballance weights, that the millionth part of an inch expanſion, or contraction, may be ſhewn; and an inſtrument formed to point out every ſtate of the cold or warmth of the air ſo minutely, as ſcarcely ever to remain ſtationary.

The bars are placed on a board of white deal, ſtraight grained, and free from knots, which was thoroughly well ſeaſoned and dry. I had it varniſhed over ſeveral times with ſtrong varniſh, or japan, to ſecure it from the moiſture of the air, which it ſeems to have done effectually. I have placed it ſeveral times in the open air, when it has rained inceſſantly for many hours, without perceiving any difference in its operation.

I found the regiſters to the thermometer ſo ſatisfactory, and the operation ſo light and eaſy, that I have alſo applied them to the wheel barometer. I had the tube A, Fig. 3. made ſomewhat above $\frac{1}{2}$ inch diameter in the hollow of the tube, with a ball B at the top, above 3 inches diameter, to the middle of which the mercury riſes at a medium. — $\frac{1}{10}$ inch mercury in this part of the ball, is ſufficient to fill 3 inches of the tube; ſo that by making one round of the pulley, on which the index is placed, $\frac{1}{10}$ inch leſs than 3 inches, it makes the riſe and fall of the mercury with more exactneſs, than any barometer, where there is not an allowance made for the ſinking or riſing of the mercury in the ciſtern, the diſtance between the two ſurfaces being the exact

height

height of the mercury. This, I believe, is ſeldom attended to in common barometers; but it requires this exactneſs in a barometer of this kind, as $\frac{1}{10}$ inch riſe or fall in the tube, is increaſed to an inch in the range of a dial-plate 10 inches diameter.

The axis of the index pulley, as alſo the regiſters, are placed on friction wheels, as thoſe of the thermometer; but it requires, that the work be made with greater nicety, in order to lay the leaſt weight on the mercury. I therefore employed Mr. Vulliamy, a watch-maker, and very ingenious mechanic, to make the machinery, which, on trial, has exceeded my expectation, as it requires but the weight of two grains to turn the regiſter and index freely.

The weight *c*, which reſts on the mercury, is made of ivory, in the ſhape of a cone, hollow within, and made narrowing towards the bottom, with a ſcrew in the middle to open; ſo that by pouring in a ſmall quantity of mercury, you may readily adjuſt its weight, which is to be ſo much heavier than the counterballance *d*, as ſerves to turn the index and regiſters. The bottom of the weight *c* is made convex, in order to meet the firſt riſe of the mercury, which is obſerved to ſwell in the middle of the tube, before it can overcome the friction occaſioned by the ſides of the glaſs, and alſo to ſink in that part firſt; by this means, a riſe or fall of 3 or 4 degrees is often obſervable, by the index of this inſtrument, when the mercury in the common barometers ſeems to continue ſtationary.

The weights *c* and *d* are ſuſpended on ſilk threads, as wound off from the cocoons. This kind of ſilk, which is not twiſted, and has the natural gum on it, probably

probably is not in any degree affected by the moiſture or dryneſs of the air. The pulley, on which theſe threads are placed, is made double: that on which the weight *e* is ſuſpended, ſurrounds one part; and the thread on which the counterballance weight *d* is ſuſpended, ſurrounds the other: ſo that when the poſition of the index is properly adjuſted, it cannot eaſily be miſplaced, the weight will always keep in its proper poſition on the ſurface of the mercury, carrying the index and regiſter, as the mercury riſes or falls in the tube.

The inward circle of the dial-plate is divided into three parts, correſponding with 3 inches generally allowed for the riſe and fall of the mercury in common barometers. Each inch is divided into twelve lines, and each line ſubdivided into ten parts, on the outward circle. The regiſters are very ſlender, and mark very diſtinctly half of theſe diviſions, which is the 240th part of an inch riſe of the mercury in the tube.

Many ſudden changes of the temperature of the air, and preſſure of the atmoſphere, have probably paſſed unnoticed, for want of ſome eaſy method of marking the variations with ſufficient preciſion. It has been accidentally remarked, that the mercury has ſunk to a great degree, and roſe very ſuddenly, during the ſhock of an earthquake; but, from the ſuddenneſs of the motion, the degrees could not be aſcertained. Any ſuch ſudden alteration, or even the common changes, will appear with ſo much certainty by the regiſters, that I ſhould imagine, inſtruments of this kind will greatly aſſiſt thoſe, who are obliged to a daily attention, in order to minute the changes

that happen with any accuracy; and yet the variations in the night-time, which I have often found greater than in the day, have generally paſſed unnoticed; particularly, in one or two ſtormy nights, I found the index point in the morning near the ſame degree it did, when I placed the regiſters; and yet it appeared, by the regiſter it carried with it, that it had fallen ſeveral degrees during the ſtorm.

I ſhould imagine the metalline thermometer might be employed to ſome uſeful purpoſes, and at no very great expence. For inſtance, a very plain inſtrument of four ſpelter bars, and three levers, might very eaſily be contrived for hot-houſes, which, by a pin fixed in the fourth bar, at a proper place, adjuſted by the botanical thermometer, might be made to raiſe a click, whenever the heat of the houſe raiſed the bar to that point, ſo as to let a ventilator operate by weights, until the air within the houſe became cool to the degree intended, by which the bars would be contracted ſo, as to draw back the click, and ſtop the ventilation; by which means, the houſe might always be kept within any two intended degrees of heat. The weight, which operates the ventilator, might be made to bear on a ſpring, when it comes near the ground, to ring an alarm bell, to warn the attendant to wind up the weight, or awake him for the purpoſe, if aſleep.

A like inſtrument might probably be applied, with great benefit, to rooms where large aſſemblies are collected, and obliged to remain a long time. The unwholſomeneſs of an over-heated air in ſuch places, has been very fully proved, by the late moſt worthy and ingenious Dr. Hales; and yet the danger of

 ſuddenly

ſuddenly throwing in too great a quantity of cold air, when the pores are opened by ſo great a degree of heat, has probably hindered the application of ventilators to this purpoſe. But, by this means, all danger on that account would be avoided with certainty, as the bars could be adjuſted to any two degrees of heat, within which, there could be no danger.

I have ventured thus far on ſpeculation, as I can have no doubt of the power of metals by expanſion; and imagine it will readily be allowed, that a ventilator may be worked by a weight, as well as by wind.

I ſend your Lordſhip a drawing of the barometer and thermometer, and have placed the inſtruments for the inſpection of the gentlemen of the Royal Society, in their meeting-room; where, if agreeable, I ſhall leave them for ſome time.

There have been ſome very ingenious methods contrived, to mark the variations that happen during the abſence of the obſerver; but I do not know, that any attempt has been made in this manner. I wiſh theſe regiſters may be found to anſwer the purpoſe; and am, with great reſpect,

My Lord,

Your Lordſhip's moſt obedient

humble ſervant,

Poland-Street,
May 6, 1761.

Keane Fitzgerald.

XXX. *An*